IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N04/4/CHEMI/HP2/ENG/TZ0/XX/M+

MARKSCHEME

November 2004

CHEMISTRY

Higher Level

Paper 2

16 pages

General Marking Instructions

After marking a sufficient number of scripts to become familiar with the markscheme and candidates' responses to all or the majority of questions, Assistant Examiners (AEs) will be contacted by their Team Leader (TL) by telephone. The purpose of this contact is to discuss the standard of marking, the interpretation of the markscheme and any difficulties with particular questions. It may be necessary to review your initial marking after contacting your TL. **DO NOT BEGIN THE FINAL MARKING OF YOUR SCRIPTS IN RED INK UNTIL YOU RECEIVE NOTIFICATION THAT THE MARKSCHEME IS FINALISED.** *You will be informed by e-mail, fax or post of modifications to the markscheme and should receive these about one week after the date of the examination. If you have not received them within 10 days you should contact your Team Leader by telephone. Make an allowance for any difference in time zone before calling.* **AEs WHO DO NOT COMPLY WITH THESE INSTRUCTIONS MAY NOT BE INVITED TO MARK IN FUTURE SESSIONS.**

You should contact the TL whose name appears on your "Allocation of Schools listing" sheet.

Note:
Please use a personal courier service when sending sample materials to TLs unless postal services can be guaranteed. Record the costs on your examiner claim form.

If you have any queries on **administration** please contact immediately:

Chris Guinee
Examinations Administration Department (EAD)
IBCA
Peterson House
Malthouse Avenue
Cardiff Gate
Cardiff CF23 8GL
GREAT BRITAIN

Tel: +44 29 20547769

Fax: +44 29 20547778

E-mail: chrisg@ibo.org

1. Follow the markscheme provided, do **not** use decimals or fractions and mark only in **RED**.

2. Where a mark is awarded, a tick (✓) should be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation in the **left hand margin** to explain your decision. You are encouraged to write comments where it helps clarity, especially for moderation and re-marking.

4. Unexplained symbols or personal codes/notations on their own are unacceptable.

5. Record subtotals (where applicable) in the right-hand margin against the part of the answer to which they refer (next to the mark allocation for Section A). Do **not** circle sub-totals. **Circle the total mark for the question in the right-hand margin opposite the last line of the answer.**

6. For Section B, show a mark for each part question (a), (b), *etc.*

7. Where an answer to a part question is worth no marks, put a zero in the right-hand margin.

8. Section A: Add together the total for each question and write it in the Examiner column on the cover sheet.
Section B: Insert the total for each question in the Examiner column on the cover sheet.
Total: Add up the marks awarded and enter this in the box marked TOTAL in the Examiner column.

9. After entering the marks on the cover sheet, check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the cover sheet. **We have script checking and a note of all clerical errors may be given in feedback to examiners.**

10. Every page and every question must have an indication that you have marked it. Do this by **writing your initials** on each page where you have made no other mark.

11. If a candidate has attempted more than the prescribed number of questions within a paper or section of a paper, mark only the required number of answers in the order in which they are presented in the script. Make a comment to this effect in the left hand margin.

12. A candidate can be penalised if he/she clearly contradicts him/herself within an answer. Make a comment to this effect in the left hand margin.

Subject Details: Chemistry HL Paper 2 Markscheme

General

- Each marking point is usually shown on a separate line or lines.
- Alternative answers are separated by a slash (/) – this means that either answer is acceptable.
- Words underlined are essential for the mark.
- Material in brackets (…) is not needed for the mark.
- The order in which candidates score marks does not matter (unless stated otherwise).
- The use of **OWTTE** in a markscheme (the abbreviation for "or words to that effect") means that if a candidate's answer contains words different to those in the markscheme, but which can be interpreted as having the same meaning, then the mark should be awarded.
- Please remember that many candidates are writing in a second language, and that effective communication is more important than grammatical accuracy.
- In some cases there may be more acceptable ways of scoring marks than the total mark for the question part. In these cases, tick each correct point, and if the total number of ticks is greater than the maximum possible total then write the maximum total followed by **MAX**.
- In some questions an answer to a question part has to be used in later parts. If an error is made in the first part then it should be penalised. However, if the incorrect answer is used correctly in later parts then "follow through" marks can be scored. Show this by writing **ECF** (error carried forward). This situation often occurs in calculations but may do so in other questions.
- Units for quantities should always be given where appropriate. In some cases a mark is available in the markscheme for writing the correct unit. In other cases the markscheme may state that units are to be ignored. Where this is not the case, penalise the omission of units, or the use of incorrect units, once only in the paper, and show this by writing **–1(U)** at the first point at which it occurs.
- Do not penalise candidates for using too many significant figures in answers to calculations, unless the question specifically states the number of significant figures required. If a candidate gives an answer to fewer significant figures than the answer shown in the markscheme, penalise this once only in the paper, and show this by writing **–1(SF)** at the first point at which this occurs.
- If a question specifically asks for the name of a substance, do not award a mark for a correct formula; similarly, if the formula is specifically asked for, do not award a mark for a correct name.
- If a question asks for an equation for a reaction, a balanced symbol equation is usually expected. Do not award a mark for a word equation or an unbalanced equation unless the question specifically asks for this. In some cases, where more complicated equations are to be written, more than one mark may be available for an equation – in these cases follow the instructions in the mark scheme.
- Ignore missing or incorrect state symbols in an equation unless these are specifically asked for in the question.
- Mark positively. Give candidates credit for what they have got correct, rather than penalising them for what they have got wrong.
- If candidates answer a question correctly, but by using a method different from that shown in the markscheme, then award marks; if in doubt consult your Team Leader

SECTION A

1. (a) $Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$ ***[2]***

*Award **[1]** for correct products, **[1]** for correct balancing.*
State symbols not required.
Accept correct equation with hydrated salt.
Accept ionic equation and partial neutralisation.

(b) $n(Na_2CO_3) = \frac{1}{2}n(HCl)$;

$n(HCl) = \frac{48.80}{1000} \times 0.1000 = 0.00488 \text{ mol}$;

concentration of $Na_2CO_3 \left(= 0.0024 \times \frac{1000}{25} \right) = 0.0976 \text{ mol dm}^{-3}$; ***[3]***

*Award **[3]** for correct answer.*
*Award **[3]** for correct answer based on equation in (a), i.e. allow ECF from (a).*
Note –1(SF) is possible.

(c) $M_r\ Na_2CO_3 = 2(22.99) + 12.01 + 3(16.00) = 105.99$;
Accept 106.

mass of Na_2CO_3 reacting with $HCl\,(aq) = 0.00244 \times 105.99 = 0.259 \text{ g}$;
Allow ECF from (b) and M_r.

mass of Na_2CO_3 in $1.000 \text{ dm}^3 = 0.259 \times \frac{1000}{25} = 10.36 \text{ g}$; ***[3]***

Note –1(U) is possible.

(d) mass of water in crystals $= (27.82 - 10.36) = 17.46 \text{ g}$;
Allow ECF from (b) and (c).

number of moles of water $= \frac{17.46}{18.02} = 0.9689$;

Accept 0.97

mole ratio $Na_2CO_3 : H_2O = 0.0976 : 0.9689$;

$x = 10$; ***[4]***

2. (a) (i) a series of (organic) chemicals with the same general formula (C_nH_{2n+2});
neighbouring members differing by CH_2;
similar chemical properties;
gradation of physical properties;
same functional group; ***[2 max]***
*Award **[1]** each for any two.*

(ii) a compound containing carbon and hydrogen only; ***[1]***

(iii) containing only single (carbon to carbon) bonds / no multiple (carbon to carbon) bonds / *OWTTE*; ***[1]***

(b) (i) boiling point increases as number of carbons increase / *OWTTE*;
increased surface area / greater Van der Waals' forces / increased M_r / increased intermolecular forces / *OWTTE*; ***[2]***

(ii) exothermic / energy released / products have less energy than reactants; ***[1]***

(c) carbon dioxide and water; ***[1]***
Both needed for mark.
Accept formulas.

3. (a) (cannot be $^{\ominus}$ as) conditions are not standard / at 500 K / *OWTTE*;
(cannot be f as) not formation from elements / is decomposition / *OWTTE*; ***[2]***

(b) change in entropy / degree of (dis)order (of system); ***[1]***

(c) $\Delta G = 177000 - (500 \times 161) = +96500$;
reaction is not spontaneous;
ΔG is positive; ***[3]***
Allow ECF from calculation for last two marks.

4. (a) $HIn(aq) \rightleftharpoons H^+(aq) + In^-(aq)$; ***[1]***
$\rightleftharpoons$ *needed for mark.*
State symbols not essential.

(b) (i) yellow as equilibrium shifts to left to remove (added) $H^+(aq)$; ***[1]***
Colour and explanation needed for the mark.

(ii) green / blue-yellow;
both HIn(aq) and $In^-(aq)$ are present; ***[2]***

5. (a) scandium and zinc / Sc and Zn; ***[1]***
Both needed for the mark.
Accept copper/Cu if given in addition to Sc and Zn i.e. all three needed for the mark.

(b) species / neutral molecules / anions which contain a non-bonding pair of electrons;
able to form coordinate/dative covalent bonds; ***[2]***

(c)

ion	$Cr_2O_7^{2-}$	$[CuCl_4]^{2-}$	$[Fe(H_2O)_6]^{3+}$
oxidation state	+6	+2	+3

Accept 6+, 2+, 3+. If given as 6, 2, 3 or (VI), (II), (III), award ***[2]*** *only.* ***[3]***

(d) V / V_2O_5 in the contact process;
Fe in the Haber process;
Ni in the conversion of alkenes to alkanes / hydrogenation reactions; ***[2 max]***
Award ***[1]*** *each for any two.*
Accept any other suitable examples.

(e) variable oxidation states;
coloured compounds;
Accept any other suitable examples. ***[2]***

SECTION B

6. (a) percentage oxygen $= 100 - (48.63 + 8.18) = 43.19\,\%$;

number of moles: C = $\frac{48.63}{12.01}$, H = $\frac{8.18}{1.01}$, O = $\frac{43.19}{16.00}$;

Accept A_r values of 12, 16 and 1.

mole ratio: C = 1.5, H = 3.0, O = 1.0;
empirical formula $= C_3H_6O_2$; ***[4]***
Allow ECF.

(b) (i) $C_3H_6O_2$;
molecular ion peak = 74 which equals molecular mass / *OWTTE*; ***[2]***

(ii) $45 = C_2H_5O^+$ / $HCOO^+$ / $COOH^+$;
$29 = C_2H_5^+$ / CHO^+; ***[2]***
Penalize absence of + sign once only.

(c) (i) absence of (broad) absorption at 2500 – 3300 cm^{-1}; ***[1]***

(ii) C–H 2840 – 3095 (3000) cm^{-1};
C=O 1680 – 1750 (1725) cm^{-1};
C–O 1000 – 1300 (1200) cm^{-1}; ***[3]***
Identity of bond and explanation needed for each mark.

(d) $HCOOCH_2CH_3$;
Accept more detailed structural formula.
ethyl methanoate;
flavouring agents / plasticizers / solvents / perfumes; ***[3]***

(e) 3;
X contains H / hydrogen atoms in three different chemical environments / *OWTTE*; ***[2]***
Allow ECF.

(f) methanoic acid;
ethanol;
esterification;
$HCOOH + C_2H_5OH \rightleftharpoons HCOOC_2H_5 + H_2O$; ***[4]***
Accept "$\rightarrow$".

(g) molecules with the same molecular formula but different structural formulas; ***[1]***

(h) CH_3COOCH_3 ;
CH_3CH_2COOH ; ***[2]***
Accept more detailed structural formulas.
Accept other correct formulas.

In (d) and (h) penalize missing H atoms once only.
Allow ECF from (a) onwards for CH_3COOCH_3.

(i) not water soluble as no (intermolecular) hydrogen bonding; ***[1]***
Accept water soluble as (small) and polar/OWTTE.

7. (a) (i) "head on" overlap of (2) orbitals;
along axial symmetry / along a line drawn through the 2 nuclei / *OWTTE*; ***[2]***
Accept suitable diagram for 2nd mark.

(ii) parallel p orbitals overlap sideways on;
above and below the line drawn through the 2 nuclei / *OWTTE*; ***[2]***
Accept suitable diagram for 2nd mark.

(iii) 1 σ and 1 π / σ and π; ***[1]***

(iv) 1 σ and 2 π / σ and π; ***[1]***

(b) (i) OF_2

sp^3;
V-shaped / bent / angular;
2 bonding + 2 non-bonding (electron pairs); ***[3]***

(ii) H_2CO

sp^2;
trigonal planar;
3 areas of electron density / negative charge centres; ***[3]***

(iii) C_2H_2

sp;
linear;
2 areas of electron density / negative charge centres; ***[3]***

Accept suitable diagrams for shapes.
Allow [2] for ECF if correct explanation given for incorrect formula, e.g. C_2H_4.

(c) (i)

Diamond	giant molecular / macromolecular / 3-D	covalent bonds only	;
Graphite	covalent bonds and van der Waals' forces	layer structure	;

[2]

*Award **[1]** for both shape and bonding in each case.*
Accept suitable diagrams.

(ii)

Diamond	Graphite	
poor / non-conductor	good conductor	;
no delocalized electrons	delocalized electrons	;
hard	soft	;
rigid structure	layers can slide	;

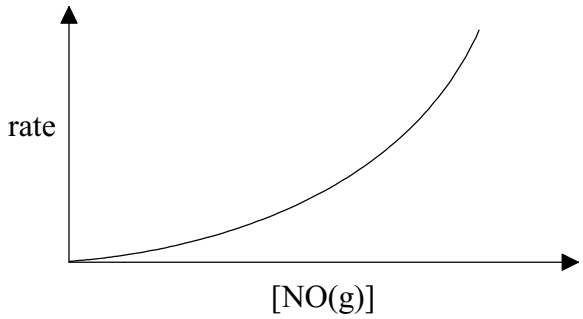
[4]

*Award **[1]** per row.*

(iii) softer than diamond / harder than graphite;
as C_{60} molecules can move over each other;
conducts better than diamond / worse than graphite;
as C_{60} has less delocalisation (of the unpaired bonding electrons) than graphite; ***[4]***

8. (a) 1 / first order;
rate is (directly) proportional to concentration of oxygen / *OWTTE*; ***[2]***

(b)



correct axes;
correct shape curve; ***[2]***

(c) 3 / third order; ***[1]***
Allow ECF from (a) and (b).

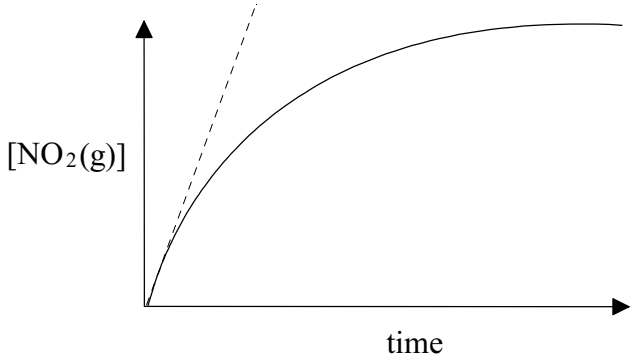
(d) overall effect on rate $= 4 \times \frac{1}{2}$ / doubled / $\times 2$;
$[NO(g)]$ doubled, rate $= \times 4$ / quadrupled;
$[O_2(g)]$ halved, rate $= \times 1$ / halved; ***[3]***
Allow ECF from (a) and (b).

(e) $\text{rate} = k[NO(g)]^2\ [O_2(g)]$;

$$k = \frac{\text{rate}}{[NO(g)]^2\ [O_2(g)]} = \frac{6.3 \times 10^{-4}}{(3.0 \times 10^{-2})^2 (1.0 \times 10^{-2})};$$

$= 70$;
$\text{mol}^{-2}\,\text{dm}^6\,\text{s}^{-1}$; ***[4]***
Allow ECF.
State symbols not needed.

(f) (i)



correct axes;
curve starts at origin and levels off;
tangent to curve at origin; ***[3]***

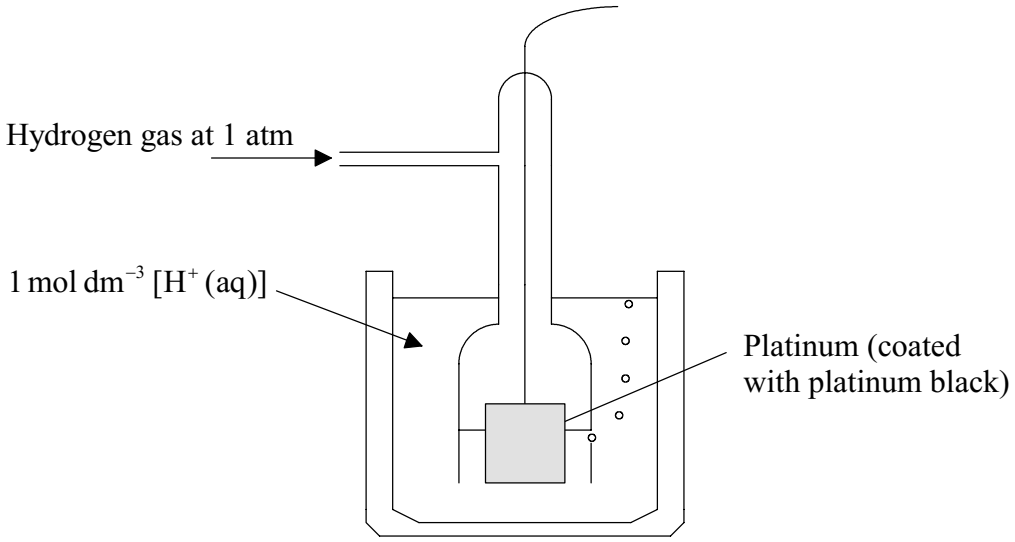
(ii) second order with respect to NO;
(Expt 1+2) double [NO(g)] only and rate quadruples;
zero order with respect to CO;
(Expt 2+3) double [CO(g)] only and rate is unchanged;
zero order with respect to O_2;
(Expt 2+4) double both [NO(g)] and $[O_2(g)]$ and rate quadruples; ***[6]***

(g) stoichiometric equation gives no indication of the reaction mechanism / *OWTTE*; ***[1]***

(h) (i) time taken for the <u>concentration</u> of a reactant to fall to half of its initial value;
half-life of a first order reaction is independent of the original concentration; ***[2]***

(ii) $t_{\frac{1}{2}} = \frac{0.693}{k} = \frac{0.693}{440} = 1.58 \times 10^{-3}\,(\text{s})$; ***[1]***

9. (a)



Accept suitable diagram with the following indicated:
Pt electrode;
1 mol dm^{-3} [H$^+$(aq)];
H_2 gas;
at 1 atm / 1.01×10^5 Pa;
298 K / 25 °C; ***[5]***

(b) electron acceptor;
$Fe^{3+}(aq)$ / iron(III) ions / Fe^{3+}; ***[2]***
Do not accept iron / Fe^{2+} / iron ion.

(c) (i) (+)1.10; ***[1]***

(ii) $Cu^{2+}(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + Cu(s)$; ***[2]***
*Award **[1]** for correct reactants and products from (c)(i), and **[1]** for state symbols.*

(d) (i) zinc;
zinc is more readily oxidised than iron and so protects it by reacting preferentially / *OWTTE* **or** tin is less readily oxidised than iron and so iron reacts preferentially / *OWTTE*; ***[2]***

(ii) charge on the ion discharged;
size / magnitude of the current;
time / duration of the electrolysis; ***[3]***

(iii) positive ions / cations in solution = $H^+(aq)$, $Zn^{2+}(aq)$;
$H^+(aq)$ discharged preferentially; ***[2]***

(e) (i) salt bridge;
allows movement of ions between the solutions / to complete the circuit / to maintain electrical neutrality; ***[2]***

(ii) $A: Fe^{3+}(aq) + e^{-} \rightarrow Fe^{2+}(aq)$;
$B: Cr(s) \rightarrow Cr^{3+}(aq) + 3e^{-}$;
*Allow **[2]** for correct equation for the cell reaction if equations for A and B are reversed.*

$3\ Fe^{3+}(aq) + Cr(s) \rightarrow 3\ Fe^{2+}(aq) + Cr^{3+}(aq)$; ***[4]***
*Award **[1]** for correct reactants and products, with state symbols, and **[1]** for correct balancing.*

(iii) from B to A / from Cr to Pt / from right to left; ***[1]***
Allow ECF from (ii).

(iv) (+)1.51; ***[1]***
Allow ECF from (ii).